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CASE REPORT

REHABILITATION OF A 23-YEAR-OLD MALE AFTER RIGHT KNEE ARTHROSCOPY AND OPEN RECONSTRUCTION OF THE MEDIAL PATELLOFEMORAL LIGAMENT WITH A TIBIALIS ANTERIOR ALLOGRAFT: A CASE REPORT

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ABSTRACT

Background: Patellar dislocations are traumatic injuries that occur most often in individuals under the age of twenty and are related to sports and physical activity. Currently, there are no published reports describing the rehabilitation of younger males after arthroscopy and open reconstruction of the medial patellofemoral ligament (MPFL) using a tibialis anterior allograft.

Case Description: The subject of this case report was a 23 year-old recreational male athlete who underwent right knee arthroscopic patellar chondroplasty, lateral retinacular release, partial lateral menisectomy, and an open MPFL reconstruction with a tibialis anterior allograft after sustaining a second patellar dislocation. The purpose of this case report is to present the functional outcomes as well as the rehabilitation strategy used during the treatment of this athlete.

Outcome: The patient returned to his prior level of activity after finishing 22 weeks of physical therapy. At a one-year follow-up, the patient reported pain-free physical activity including weight training, running, and recreational basketball.

Discussion: The results of this four-phase rehabilitation program with this subject were excellent. However, research beyond single subject case reports on post-operative rehabilitation for knee arthroscopy and open MPFL reconstruction with a tibialis anterior allograft is lacking. This is the first report that describes a rehabilitation strategy for this procedure. Although there was a successful rehabilitation outcome, future research is necessary to establish optimal rehabilitation guidelines as well as normative milestones for individuals who undergo this surgery.

Key Words: Patellofemoral; ligament; dislocation; instability; rehabilitation

Level of Evidence: 4-Case Report

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BACKGROUND

Patellar dislocations occur mostly in younger individuals under the age of twenty and are often related to sports and physical activity.[1,2] Dislocations occur as a result of trauma whereby the patella travels out of the normal position in the patellofemoral (trochlear) groove. Often, a dislocated patella does not spontaneously return to normal position in the trochlea, in contrast to a subluxed patella where the patella may only partially travel out of the groove.[3] Lateral patellar dislocations (patella slips over lateral groove) are the most common type of patellar dislocations and may result in damage to the medial patellofemoral ligament (MPFL), medial retinaculum, vastus medialis oblique, and the articular cartilage of the patella and trochlea.[3] Dislocations typically occur from direct trauma to the patella or a sudden twist of the slightly flexed knee during weight bearing activity.[4]

Acute patellar dislocations account for about 3% of all knee injuries and are the second highest cause of knee hemarthrosis.[5] The highest incidence of patellar dislocations is in females 10 to 17 years of age.[6] It has been reported that the initial diagnosis of a patellar dislocation is often overlooked by as much as 45 to 73% of cases.[3] Without advanced imaging, the clinical diagnosis is often elusive, outside of recognizing patellar instability.[7-9]

Individuals with a prior history of dislocation are seven times more likely to experience episodes of patellar instability than first time dislocators.[6] A search of the literature reveals no consensus on the number of dislocations that qualify as "recurrent" or "frequent". Primary and recurrent dislocations can be linked to several predisposing factors including: patella alta, increased quadriceps angle, trochlear dysplasia (hypoplasia), vastus medialis oblique atrophy, MPFL insufficiency, increased patellar tilt, genu recurvatum, increased femoral anteversion, external tibial torsion, foot pronation, and patellar hypermobility.[5,10,11]

Operative versus non-operative management of patellar dislocations remains under debate due to the lack of high quality evidence that confirms any difference between the approaches.[5,11,12] Acute surgical indications include osteochondral fragments, persistent patellar dislocation and subluxations, detachment of the medial retinaculum and vastus medialis oblique from the medial patella. Surgical indications for patients with chronic instability involve addressing the predisposing factors that affect patellar function such as MPFL insufficiency.[10] The ideal candidate for surgery is an individual that seeks medical care for recurrent instability with minimal pain or patellofemoral pain that is directly related to the episodes of instability.[13]

The non-operative management of patellar dislocations may not always be successful with recurrent dislocation rates reported in up to 44% and the incidence of chronic instability being greater than 50% in individuals with a history of one or more patellar dislocation.[5] This may be due to the disruption of the MPFL, which has been found to provide 50 to 60% of the restraining force against lateral patellar translation especially between 20 to 30 degrees of knee flexion.[14-16] Clinically, it has been found that the MPFL is disrupted to varying degrees in 94 to 100% of first time patellar dislocations and that damage to the MPFL has been shown to be a predictor of recurrent dislocations.[1,4,17]

Several authors have described positive outcomes for surgical reconstruction of the MPFL in individuals who experienced recurrent dislocations.[18,19,20] Nelitz et al[18] demonstrated significant improvement ($P < .01$) on the visual analog scale (VAS), the Kujala knee function scale, and the International Knee Documentation Committee (IKDC) scale after reconstruction of the MPFL using a gracilis tendon autograft in a group of 21 patients (mean age 12.2 years) with an average 2.8 year follow-up. No recurrent dislocations occurred in the group but two patients with high grade trochlear dysplasia retained the presence of an apprehension sign. Other authors have found similar positive outcomes using hamstring allografts and autografts with no incidence of redislocations after MPFL reconstruction.[19,20] Despite this recent evidence, long-term outcomes are still needed to further confirm the efficacy of this procedure.

A search of the literature in PubMed, CINAHL, ProQuest and Google Scholar® revealed two clinical commentaries regarding non-surgical interventions,[21,22] one commentary on non-specific post-surgical rehabilitation,[23] a case report on post-operative care after MPFL hamstring allograft,[24] a case report on post-operative care after trochleoplasty,[25] and two systematic reviews on post-operative rehabilitation,[26,27] Currently, to the author's knowledge, there are no published reports describing the post-operative rehabilitation for open repair of the MPFL using a tibialis anterior allograft. Due to the paucity of literature, a detailed description of the proposed rehabilitation for use after this surgical procedure is necessary. The purpose of this case report is to present the outcomes and rehabilitation strategy used for a 23 year-old male who underwent right knee arthroscopic patellar chondroplasty, lateral retinacular release, partial lateral menisectomy, and open MPFL reconstruction with a tibialis anterior allograft.

CASE DESCRIPTION

The patient participated in high school football (e.g. offensive lineman position) and suffered his first right knee injury during his junior year. During practice, the patient suffered a non-contact knee injury. He planted and twisted his knee resulting in immediate pain and swelling. The patient saw an orthopedic surgeon and was subsequently referred for a magnetic resonance imaging (MRI) scan without contrast which indicated a peripheral tear of the anterior horn of the lateral meniscus and damage to the medial retinaculum which was consistent with a transient lateral dislocation of the patella. The patient underwent non-surgical management for 6-weeks with physical therapy which included wearing a Palumbo® (Palumbo, Inc. Irving, TX) patellar stabilizing brace during physical activity. The patient was able to resume sports participation and physical activity without additional incidences of dislocation. Approximately 7 years later, the patient suffered a second patellar dislocation when he collided with another player during a recreational basketball game. The patient saw an orthopedic surgeon and was subsequently referred for a MRI scan without contrast which indicated signs of a prior transient patellar dislocation with persistent subluxations of the patella, including trabecular bone injury of the lateral femoral condyle, and a shallow trochlear groove (Figure 1). Based upon the results of the MRI and clinical findings the patient elected to undergo surgical intervention.

In July 2012, the patient underwent right knee arthroscopic patellar chondroplasty, lateral retinacular release, partial lateral menisectomy, and open MPFL

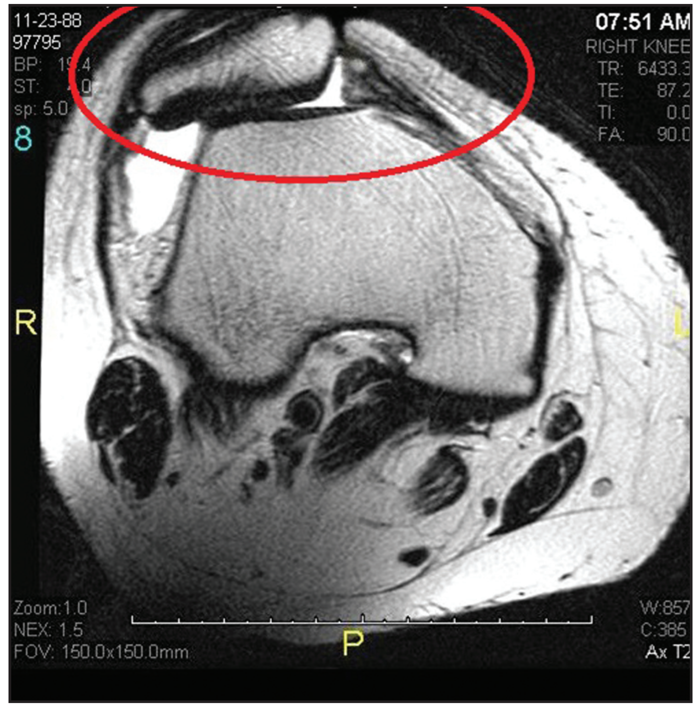

Figure 1. *MRI of right knee.*

reconstruction with a tibialis anterior allograft. The patient did not undergo a trochleoplasty for his shallow trochlear groove, which is an emerging procedure that is often combined with repair of the MPFL in patients with trochlear dysplasia.[28] Researchers have reported incidences of post-operative patellar instability and dislocations in patients with moderate to severe trochlear dysplasia who underwent repair of the MPFL without trochleoplasty.[29-31]

INITIAL EXAMINATION

The patient was seen in physical therapy for the initial examination approximately two weeks after surgery. The patient was a healthy 23 year-old male with a mixed endomorphic-mesomorphic build (Body mass-135.17 kg, Height-182.88 cm, Body Mass Index- 40.4). The patient reported no symptoms of patellar instability and was taking Voltaren® (50 mg) and Norco® (7.5 mg/325 mg) for pain control, as needed. The patient ambulated with a knee brace locked at 0°, full weight bearing with axillary crutches. Precautions restricted the patient from flexing his knee beyond 90 degrees for the first 4 weeks post-operatively, which was based upon the surgeon's preferential guidelines versus a biomechanical explanation. Researchers have found that the MPFL has a primary role of guiding the patella in the trochlear groove during the first 20-30 degrees of knee flexion.[32,33] The MPFL also has an additional stabilizing role with greater knee flexion angles. Higuchi et al[34] examined the non-weight bearing length change patterns of the MPFL in vivo in 20 healthy adult volunteers (10 male, 10 female) from full knee extension to a knee flexion angle of 120 degrees via MRI. They found that the MPFL contributes to medial stability of the patella from 0-60 degrees of flexion with the strongest strain at 60 degrees. This research provides some evidential support for the use of a post-operative ROM limitation. However, there is no consensus in the literature regarding the 90 degree flexion limitation, thus the decision was based primarily on the suggested treatment after the arthroscopic surgical procedure and associated discomfort typically experienced at higher knee flexion angles in the acute stages. The examination and subsequent interventions were carried out by a physical therapist with 10 years of experience and a board certification in orthopedics. The examination findings are outlined below.

Subjective & Observation

The patient reported that his primary goals were to return to pain-free physical activity, weight training, and recreational basketball. At the time of examination, the primary complaint was knee stiffness and pain around and within the knee joint. A review of the patient's history revealed no current or prior lower extremity injuries or co-morbidities that would impede rehabilitation. He denied pain or discomfort at the neighboring joints and had no reports of paresthesias or general malaise. Inspection of the incision site revealed adequate healing with the steri- strips intact over the anteromedial and anterolateral arthroscopy portals. Inspection of the medial incision site revealed an approximate 5.3 cm longitudinal incision midway between the medial femoral condyle and the patella covered with steri-strips that were intact and demonstrated adequate healing. Mild knee effusion was present upon inspection. A general static postural screen was conducted in standing which revealed right lower extremity external rotation and bilateral pes planus alignment (Figure 2). The patient confirmed wearing custom orthotics during physical activity.

Self-Report Measures

An 11-point numerical pain rating scale (NPRS) with 0 (no pain) to 10 (worst pain imaginable) was used to elicit an objective ranking of the patients

Figure 2. *Standing postural screen.*

pain level.[35,36] During the past 24 hours, the patient reported his pain to be 6/10 at worse and 1/10 at best. At the time of the examination his pain was rated as 4/10. The patient also completed the Lower Extremity Functional Scale (LEFS) to obtain a better understanding of his functional abilities.[37-39] The patient scored a 13 out of 80 (16%) scaled points and reported difficulty with most activity due to his post-operative status. Both the LEFS and NPRS were used as repeated measures of function throughout the rehabilitation process.

Range of Motion and Muscle Performance

The patient's hip, knee, and ankle range of motion (ROM) were tested both actively and passively as described by Norkin & White.[40] Bilateral measurements were within normal limits (WNL) and symmetrical with the exception of the right knee. The patient was apprehensive with movement of the right knee but agreed to perform both active range of motion (AROM) and passive range of motion (PROM). AROM of the right knee revealed flexion to 90 degrees with a 10-degree loss of knee extension. PROM revealed flexion to 90 degrees and a 5-degree loss of extension which may have been from the knee joint effusion. Muscle performance of the lower extremities was quantified (Table 1) using manual muscle testing as described by Hislop and Montgomery.[41] The right quadriceps was measured 2+/5; however no confrontational resistance was added due to the patient's post-operative status.

Palpation
Palpation of the right knee region was assessed using a 5 point pain scale (Grade 0-4) as described by Hubbard and Berkoff.[42] The grading criterion is as follows: grade 0 - no tenderness, grade I - mild tenderness without grimace or flinch, grade II - moderate tenderness plus grimace or flinch, grade III - severe tenderness plus marked flinch or withdrawal, grade IV - unbearable tenderness, patient withdrawals with light touch.[42] Palpation of the patient's right knee revealed grade I (mild) tenderness along the quadriceps tendons, pes anserine group insertion, and distal insertion of the iliotibial band. The patient had increased walking activity with axillary crutches for several consecutive days prior to the initial examination, which may have explained the mild knee effusion and palpable tenderness.

Special Testing
Muscle length testing was performed to determine the nature of the patient's extension loss and revealed length impairments of both the gastrocnemius and hamstrings. Muscle length testing was deferred at the quadriceps due to the post-operative movement restrictions. Observed patellar tracking was good with the absence of a J-sign during AROM and PROM knee flexion and extension. The patellar apprehension test was also negative upon testing. A neurovascular screen of the lower extremity revealed no significant findings.

Assessment and Evaluation
At the time of the initial examination, the patient was approximately two weeks post-surgery. The examination findings revealed impairments and functional limitations that were consistent with Practice Pattern 4I from the Guide to Physical Therapist Practice: *Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated With Bony or Soft Tissue Surgery,*[43] It was determined that the patient would benefit from a structured rehabilitation program to improve impairments and address functional limitations.

INTERVENTION PLAN

Plan of Care
The rehabilitation program (Table 2a, 2b) was based on a four-phase protocol, which was designed using clinical experience and collaboration with the patient's orthopaedic surgeon. Due to the paucity of rehabilitation literature for MPFL repair, the authors followed a phased structure similar to those reported in the descriptive literature.[23,24,25] Trunk stabilization and general lower kinetic chain exercises were integrated into the program consistent with the regional interdependence model.[44]

Table 1. *Muscle Performance Testing.*

	Initial 2 Weeks Post-Op		Reassessment 12 Weeks Post-Op		Discharge 22 Weeks Post-op	
Muscle Groups	Right	Left	Right	Left	Right	Left
Hip flexors	5/5	5/5	5/5	5/5	5/5	5/5
Hip extensors	4/5	4/5	4+/5	4+/5	5/5	5/5
Hip abductors	3+/5	4/5	4/5	4+/5	5/5	5/5
Hip adductors	3/5	5/5	4+/5	5/5	5/5	5/5
Hip external rotators	3+/5	4/5	4/5	4+/5	5/5	5/5
Hip internal rotators	4/5	4+/5	4+/5	5/5	5/5	5/5
Knee extensors	2+/5	4+/5	4/5	5/5	5/5	5/5
Knee flexors	3+/5	5/5	4+/5	5/5	5/5	5/5
Ankle dorsiflexors	5/5	5/5	5/5	5/5	5/5	5/5
Ankle plantarflexors	5/5	5/5	5/5	5/5	5/5	5/5

Table 2a. *Rehabilitation Program: Phase I and Phase II*

Phases of Rehabilitation	Program Details
Phase I	**Focus**: Protect the surgical site, restore AROM and PROM, control pain & inflammation, normalize gait, and improve neuromuscular control and muscle performance. **Precautions**: Avoid pivoting or twisting the knee, limit knee flexion to 90 degrees for the first 4 weeks, use of axillary crutches with brace locked to 0° during ambulation until adequate quadriceps control is appreciated, and to avoid undue pain and stress to the surgical site.
	Criteria to Advance to Phase II: No signs or symptoms of patellar instability, knee ROM 90° or greater (after 4 weeks), full knee extension, active quadriceps contraction, heel to toe gait pattern with unlocked brace, no assistance of crutches, and minimal to no joint effusion.
	Range of Motion: Stationary bike with seat high (no pedal straps), towel slides, ankle pumps. **Muscle Performance**: Neuromuscular Electrical Stimulation (paired with quad sets), isometrics for the leg (e.g. hamstring sets), straight leg raise (wearing knee brace), three way leg raises (abduction, adduction, and hip extension), standing calf raise (single and bilateral), sidelying clams, double leg bridges.[50] Closed Kinetic Chain Exercise (CKC) exercises included ¼ squats and leg press.[62] **Proprioception**: Single limb balance (wearing brace) on stable surface.[64] **Abdominal Core**: Transversus abdominal exercises. **Stretching**: Iliotibial band, hamstrings and gastrocnemius/soleus. **Manual Therapy**: Soft tissue management of the right lower extremity with emphasis on the quadriceps, hamstrings, and iliotibial band tract. Passive range of motion and grade I and II superior and inferior patellar glides. **Modalities**: Interferential Electrical Current (IFC) and ice for swelling. **Home Program**: Daily pain-free AROM and PROM to 90 degrees of flexion (4 weeks), basic LE strengthening with no open chained activity at knee.
Phase II	**Focus**: Protect the surgical site; continue to restore ROM and gait, and improve muscle performance by progressing CKC exercises in single plane motions. **Precautions**: Avoid pivoting or twisting the knee, overstressing the surgical site, multiplanar movements, closed chain movements with deep knee flexion angles (>90°), and wearing the brace during activity.
	Criteria to advance to Phase III: No signs or symptoms of patellar instability, adequate quadriceps strength (i.e. absence of extensor lag during straight leg raise), knee ROM 120° or greater, single leg balance 30 seconds or greater, normal gait pattern with unlocked brace, minimal to no joint effusion.
	Range of Motion: Phase I activity. **Muscle Performance**: Phase I activity with the progression of CKC exercises which included: bilateral squats on TRX® suspension trainer, side stepping, ¼ lunges (sagittal and frontal plane), step-up onto 4 inch step, heel walking, and toe walking. **Proprioception**: Single limb balance on unstable surface (e.g. mini trampoline, Airex® pad).[64,65] **Abdominal Core**: Basic exercises (e.g. front and side planks). **Stretching**: Phase I stretching continued. **Cardiovascular**: Elliptical & stationary bicycle. **Manual Therapy**: Soft-tissue and joint mobilization, as needed. **Modalities**: IFC (pain and swelling) and ice. **Home Program**: Phases I and II activity and the addition of cardiovascular conditioning with the elliptical trainer and stationary bike.[66]

Table 2b. *Rehabilitation Program: Phase III and Phase IV*

Phases of Rehabilitation	Program Details
Phase III	**Focus**: Restore full joint ROM, muscle performance, improve proprioception, and introduce sports specific movements. **Precautions**: Avoid overstressing the surgical site, closed chain movements with deep knee flexion angles (>90 degrees), and post exercise swelling and pain.
	Criteria to Advance to Phase IV: No signs or symptoms of patellar instability, minimal to no joint effusion, improved quadriceps strength (i.e.; 4+/5), normal knee ROM, normal jogging pattern while wearing brace, and clearance by surgeon.
	Range of Motion: As needed to restore full range of motion **Muscle Performance**: Phase II activity with the addition of multidirectional CKC exercises and hamstring strengthening with machines. Sports specific activity included light jogging patterns (with brace) and movement patterns with the agility ladder. **Proprioception**: Single limb balance progression using air-filled discs and the Bosu® balance trainer.[64] **Abdominal Core**: Continuation of basic exercises (e.g. (e.g. front and side planks). **Stretching**: Phase I & II stretching as needed. Quadriceps stretching and self-myofascial release techniques (i.e., foam roll, hand-held roller) were introduced with emphasis on the rectus femoris, hip flexors, tensor fascia lata, adductors, and abductors. **Cardiovascular**: Elliptical and incline treadmill for conditioning. **Manual Therapy**: Soft-tissue and joint mobilization, as needed. **Modalities**: None **Home Program**: Phases I to III activity, continued with cardiovascular conditioning with the elliptical and incline treadmill. [66]
Phase IV	**Focus:** Returning to full sports activity. **Precautions**: Pain free activity and avoid post exercise joint effusion.
	Criteria to Return to Full Activity: No signs of symptoms of patellar instability, absence of joint effusion, normal lower extremity strength, normal neuromuscular control with all sports specific testing, and clearance by surgeon.
	Range of Motion: Phases I to III activity as needed. **Muscle Performance**: Phases I to III activity as needed. Begin sports specific activity including low-level plyometrics, multi-directional agility drills, and circuit training. **Abdominal Core**: Progressive core strengthening exercises. **Stretching**: Phases I to III activity as needed with the addition of a lower extremity neuromuscular warm-up routine.[54,63] **Cardiovascular**: Elliptical, stationary bike, and progressive jogging. **Manual Therapy**: Soft-tissue and joint mobilization, as needed. **Modalities**: None **Home Program**: Phase III to IV activity and the addition of jogging for cardiovascular conditioning.

POST-OPERATIVE REHABILITATION

Phase I

The focus of Phase I was to protect the surgical site, restore AROM and PROM, control pain and inflammation, restore normal gait without an assistive device, and improve neuromuscular control and muscle performance. Phase I began two weeks post-operatively and was based on the specific guidelines from the surgeon and collaboration with the evaluating physical therapist (Table 2a). Recommended precautions included: avoid pivoting or twisting the knee, limiting knee flexion to 90 degrees for the first four weeks, use of axillary crutches with brace locked to 0° during ambulation until adequate quadriceps control is appreciated, and to avoid undue pain and stress to the surgical site. For the purposes of this case report the authors defined surgical site stress as symptoms of pain or signs of effusion after therapeutic exercise.

During Phase I, care was taken to protect the surgical site and limit knee ROM based on the surgeon's preference. Also, the patient was closely monitored for any bouts of instability. Closed chained activity was closely monitored especially with ranges from 0 to 30° of knee flexion since the trochlear groove is a major stabilizer for the patellofemoral joint at those ranges.[45] Manual therapy included grade I and II superior and inferior patellar glides. Medial and lateral joint glides were not performed in order to avoid stressing the surgical site. During the first week, neuromuscular electrical stimulation (NMES) was used in conjunction with isometrics for muscle re-education (50 pulses per second, 10 seconds on, 30 seconds off).[46,47] Interferential electrical current (IFC) with ice was also used for pain control and to prevent post exercise swelling (using IFC preset protocol for pain and swelling for 15 minutes), as needed.[48,49] The patient's home exercise program included pain-free AROM and PROM to 90 degrees of flexion for the first four weeks, basic lower extremity strengthening and avoidance of open kinetic chain activity at the knee in order to protect the surgical site.[45] The patient was weaned off crutches after two weeks and ambulated with his brace unlocked at four weeks post-operatively. The patient was seen for physical therapy an average of two times per week. At six weeks post-operative, the patient met the criteria to advance to Phase II which included: no signs or symptoms of patellar instability during activities performed in Phase I, knee ROM 90° or greater, full knee extension, active quadriceps contraction, heel to toe gait pattern with unlocked brace, no assistance of crutches, and minimal to no joint effusion.

Phase II

The focus of Phase II was to continue to protect the surgical site, continue to restore joint ROM, normalize his gait pattern, as well as improve muscle performance by progressing closed kinetic chain (CKC) exercises in single plane motions. Phase II began 8 weeks post-operatively which continued to include collaboration between the surgeon and the physical therapist (Table 2a). Recommended precautions included: avoid pivoting or twisting the knee, overstressing the surgical site, multiplanar movements, and closed chain movements with knee flexion angles >90 degrees, and that the patient should continue to wear the brace during activity.

Due to the patient's clinical presentation of bilateral pes planus and considerable genu valgus angle (Fig. 2), maintaining proper lower extremity alignment during closed chain activity was stressed. Exercises focusing on the hip and abdominal core were added which have been associated with improved lower extremity function and reduction of pain in patients with patellofemoral pain syndrome.[50,51] The patient also wore his custom orthotics during activity. Research suggests that foot orthoses may help reduce pain in patients with anterior knee pain thus combining therapeutic exercise and orthoses may produce better outcomes than orthoses alone.[52,53]

On two occasions during Phase II, IFC (as described previously) and ice were used as a result of knee discomfort following exercise.[48,49] The patient's home exercise program included Phase I and II activity and the addition of the elliptical trainer or stationary bike using moderate resistance for 20 minutes. At 12 weeks post-operative, the patient met all criteria to advance to Phase III which included: no signs or symptoms of patellar instability during activity, adequate quadriceps strength (i.e. absence of extensor lag during straight leg raise), knee ROM 120° or greater, single leg balance 30 seconds or greater, normal gait pattern with unlocked brace, and minimal to no joint effusion.

Reassessment

The Lower Extremity Functional Scale (LEFS) was given again to reassess the patient's functional abilities at this point in his rehabilitation. The patient scored a 66 out of 80 (83%) scaled points and reported difficulty with higher-level activities such as sports, hopping, and running. This was a 53-point improvement since the pre-intervention assessment (i.e. 13 out of 80 scaled points). The minimal detectable change and minimal clinically important difference is 9 scale points.[39] The patient's phase of healing and current restrictions were considered when interpreting the results. The patient reported an occasional 2/10 pain on the NPRS (local to the surgical site) after strenuous exercise and 0/10 pain with Activities of Daily Living (ADL's). The patient's knee range of motion was measured and found to be 2-0-123° (extension-neutral-flexion). Manual muscle testing was also conducted at this time (Table 1).

Phase III

The focus of Phase III was to restore full joint ROM, muscle performance, improve proprioception, and introduce sports specific movements. Phase III began 12 weeks post-operatively (Table 2b). Recommended precautions included: avoid overstressing the surgical site, closed chain movements with deep knee flexion angles (>90 degrees), and post exercise swelling and pain.

During this phase, multidirectional CKC exercises were introduced with light jogging patterns and ladder drills. Phase III was considered a transitional phase to prepare the patient for more advanced activity in Phase IV. The patient responded well to treatment during this phase with no refractory occurrences or need for modalities. The patient's home exercise programs included Phase I-III activities with the continuation of the elliptical and the addition of the incline treadmill for cardiovascular conditioning. At 18 weeks post-operative, the patient met all criteria to advance to Phase IV which included: no signs or symptoms of patellar instability, minimal to no joint effusion, improved quadriceps strength (i.e.; 4+/5), normal knee ROM, normal jogging pattern while wearing brace, and clearance by the surgeon.

Phase IV

The focus of Phase IV was for the patient to return to full sports activity. Phase IV began 18 weeks post-operative (Table 2b). Recommend precautions included maintaining pain-free activity and avoidance of post exercise joint effusion. Criteria to return to full activity included: no signs and symptoms of patellar instability, absence of joint effusion, normal lower extremity strength, normal neuromuscular control with all sports specific testing, and clearance by surgeon.

Due to the patient's morphological build, a custom patellar tracking brace from Breg® (Breg, Inc. Carlsbad, CA) was ordered to further protect the surgical site during sports activity (Figure 3A, 3B). During Phase IV, multidirectional sports specific activity was progressed with the introduction of the Prevent Injury and Enhance Performance (PEP) program, which has been shown to reduce incidents of lower extremity injury in younger males and females.[54] The patient responded well to treatment during this phase with no adverse occurrences. The patient's home exercise program included Phase I-IV selective activity with the addition of jogging (Figure 4) for cardiovascular conditioning. At 22 weeks post-operative the patient met all criteria for Phase IV and was cleared to return to gym and recreation sports activity.

OUTCOMES

Discharge

At the time of discharge the patient diminished his body mass (Body mass-111.13 kg, Body Mass Index-33.2.) and scored 76 out of 80 (95%) on his final reassessment with the LEFS which was 10 points higher than the mid-term assessment (i.e., 66 out of 80). The patient reported only minimal difficulty with sports activity, hopping, and sharp turns while running. The patient's brace was worn during all sports activity and was considered by the patient when reporting the outcomes from the LEFS. The patient also reported 0/10 pain on the NPRS with activities of daily living, light weight training, and sports activity. The right knee ROM was 5-0-128° and all lower extremity manual muscle tests were graded a 5/5 (Table 1). Muscle length & myofascial mobility was normal except for mildly decreased quadriceps length during prone knee flexion.

Follow-up (1 year)

At one year the patient was contacted via phone and reported returning to pain-free physical activity

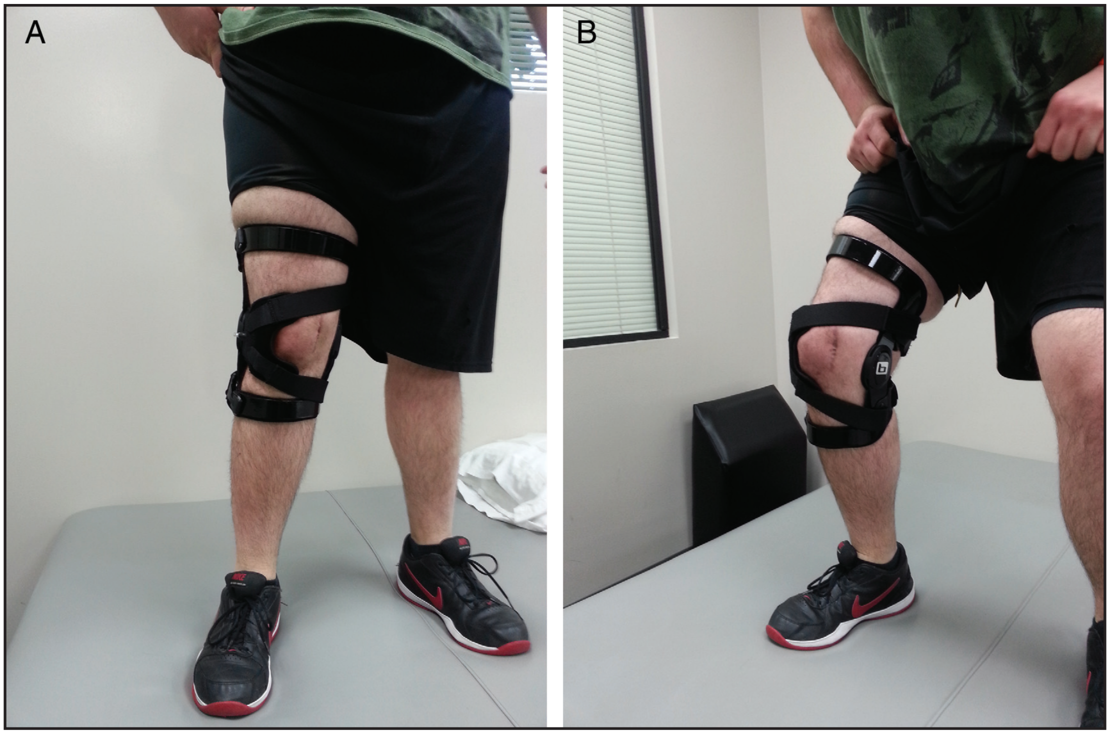

Figure 3A, 3B. *Patellar maltracking brace.*

including weight-training, running, and recreational basketball. The patient continues to wear the brace as a precaution and has experienced no adverse events such as patellar instability since discharge.

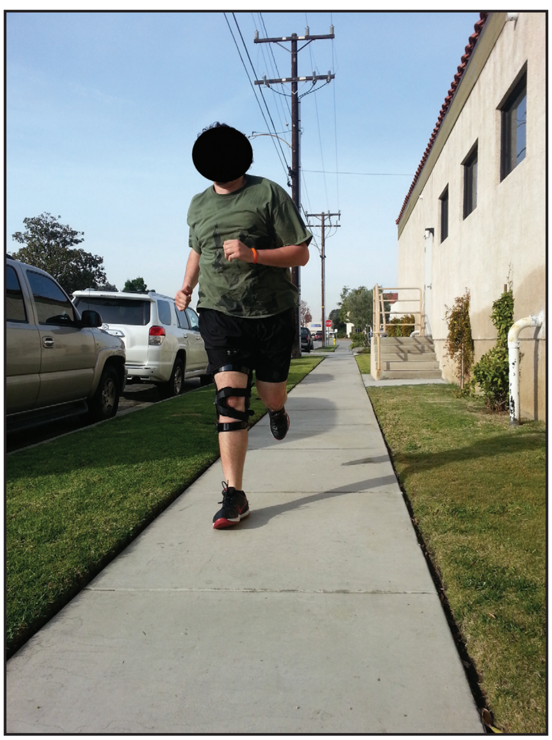

Figure 4. *Jogging with brace.*

DISCUSSION

This case report describes the outcomes of a structured rehabilitation program for a young adult male after right knee arthroscopy and open MPFL reconstruction using a tibialis anterior allograft. The unique nature of this case is the combined arthroscopic procedure with the open MPFL reconstruction with a tibialis anterior allograft, which has only recently been reported in a non-English publication.[55] Traditionally, the hamstring and gracillis autograft and allograft have been the tissues of choice by surgeons.[55-57] The tibialis anterior allograft has been successful for anterior cruciate ligament (ACL) reconstruction and has shown similar biomechanical qualities to the hamstring and gracillis allografts.[58,59]

Surgical interventions to address patellofemoral instability are still evolving and have shown mixed outcomes. A recent systematic review by Shah et al[29] confirms a high success rate with MPFL reconstruction using either the hamstring or gracillis graft but also notes a surgical complication rate of 26.1%. Adverse events included patellar fracture, surgical failures, and loss of knee flexion, wound complications, pain, and clinical instability on postoperative exams.[29] Thus, patient selection and surgeon familiarity should be considered before having MPFL reconstruction. Also, long-term studies are still needed to further confirm the efficacy of the MPFL reconstruction procedure and the specific graft selection.

Other clinical factors unique to this case report include the patient's weight loss and use of the custom brace. The patient's weight loss could have influenced his overall improvements in mobility and function. This is contrary to other reports that have found no correlation between patellar dislocations and being overweight or sedentary in younger individuals.[60] However, further studies are needed to confirm these finding especially with taller, larger individuals who actively participate in physical activity. Post-operative bracing is atypical for this procedure in the authors' practice since most patients are cleared by the referring surgeons to return to function or sports activity without a brace. The potential risk for future dislocations due to the patient's morphology (e.g. shallow trochlear groove) was considered when ordering the custom knee brace. Currently, there is no research to confirm this clinical practice. Prior to wearing the brace, the patient was apprehensive about engaging in sports specific movements that involved multidirectional activities due to the related symptoms of instability he previously experienced. This is a common finding among patients with patellar instability who participate in activities that involved multiplaner movements versus uniplanar movements.[61]

The rehabilitation program presented provides general guidelines, which should be modified in order to meet each patient's individual needs and functional abilities. The available research on post-operative rehabilitation is inconclusive. Smith et al[26] conducted a systematic review investigating early rehabilitation (0-4 weeks) of patients who underwent open or arthroscopic MPFL reconstruction for patellar instability. The authors specifically inquired about the optimal post-operative weight bearing status, the use of knee bracing, and the optimal time to introduce therapeutic exercise. After their review of the literature, they concluded that there was insufficient evidence regarding the optimal post-rehabilitation program and not enough evidence to draw firm conclusions.[26] Thus, further controlled trials are needed to develop the optimal rehabilitation program for individuals who undergo open or arthroscopic MPFL reconstruction.

CONCLUSION

Research on post-operative outcomes and the rehabilitation after arthroscopy and open MPFL reconstruction using the tibialis anterior allograft is lacking in the literature. This is the first case report reporting outcomes after this procedure as well as after the four-phase rehabilitation program suggested by the authors. The program was based on the authors' clinical experience with this type of injury as well as collaborative input from the surgeon. There is an ongoing need to establish more evidence based rehabilitation programs for open MPFL reconstruction procedures as there is no basis for comparing this patient's outcomes or progress to alternative intervention plans.

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